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THE EFFECT OF IRRIGATION RETURN WATER ON THE BENTHIC MACROINVERTEBRATES OF THE LOST RIVER OREGON-CALIFORNIA

Federal Water Pollution Control Administration
San Francisco, California

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ABSTRACT

The Klamath Basin Study, a special project of the Federal Water Pollution Control Administration, is studying the effects of nutrients originating from agricultural land drainage upon recreation, water supply and Federal wetlands and wildlife management areas. The effects of this drainage on the benthos of this system are cumulative. Changes in the association of benthic organisms were then compared from one valley to the next on a downstream basis. These comparisons of benthic communities displayed a definite downstream change from clean water associated to pollution tolerant communities from the upstream most to the downstream most agricultural valley.

KBS Technical Paper No. 2
Kreis and Johnson
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INTRODUCTION

A survey of the benthic macroinvertebrates was made on the Lost River system to determine the effects of irrigation return water on these organisms.

This survey is a part of an overall investigation to determine the causes of past extensive wildfowl kills on the Tule Lake and Lower Klamath National Wildlife Refuges located within the Lost River system. One of the Klamath Basin Study's objectives is to determine the effects of nutrients originating from agricultural land drainage upon recreation, water supply and Federal wetlands and wildlife management areas. The effects of the agricultural wastes were determined by evaluating their impact on the communities of benthic organisms (macroinvertebrates) in the Lost River system.

A study of the ecology of benthic macroinvertebrates in the system provided a measure of pollution of past and present water quality conditions because many benthic organisms living in the Lost River have life cycles of a year or more, limited mobility and varying degrees of sensitivity to the effects of irrigation return water. Therefore, this benthic macroinvertebrate survey reveals the variations in chemical and physical conditions which occurred during the survey period.

The use of ecological studies of benthic macroinvertebrates in pollution investigations has been described by Bartsch and Ingram (1959)[1], T. W. Beak, (1964)[2] , Gaufin and Tarzwell (1953)[3], Keup, Ingram and Mackenthun (in press)[4], and Usinger (1956)[5], et. al.

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FINDINGS

1. Agricultural drainage was found to have a cumulative effect on the benthic macroinvertebrate communities. During all three sampling periods at the upstream most station, mile point 94.3, an average of eleven kinds of clean water associated organisms were found to one pollution tolerant kind of organism. Near the mid point of the System, mile point 54.7, the average number of clean water associated kinds of organisms was equal to the number of pollution tolerant kinds. The downstream most station, mile point 2.25, there were three pollution tolerant kinds and one clean water associated kind.

2. Populations of caddisfly and mayfly nymphs, beetle larvae and aquatic moth caterpillars were found in the clean water upstream reaches of the System, mile points 54.7 to 94.3, and populations of sludgeworms, bloodworms, and leeches were found in the polluted downstream reaches of the System, mile points 2.25 to 54.7.

3. The total number of organisms were as high as 580 per square foot in the clean water areas of the upstream reaches and reached a high of as many as 1,829 in the polluted downstream reaches of the System.

4. Changes in the number of organisms per square foot were found to be associated with agricultural water use. The number of organisms collected in upstream reaches were clean water associated and remained less than 600 per square foot during all sampling periods. In April before the irrigation season, the average number of organisms collected in the downstream reaches were pollution tolerant species such as bloodworms and sludgeworms and were less than 215 organisms per square foot. In August and December the average number of organisms collected in the downstream reaches were pollution tolerant species and increased to over 1,000 and 1,800 per square foot, respectively. These increases in numbers of pollution tolerant organisms were due to the increase in irrigation return water and the reuse of this water.

5. The effects of riffle areas, water held in reservoirs and sumps, and the addition of clean water from springs, Upper Klamath Lake and the Klamath River improved the quality of the Lost River System. This improvement was reflected by a change in the composition of benthic macroinvertebrate populations from pollution tolerant species such as sludgeworms, bloodworms and leeches to clean water associated species such as mayfly nymphs and beetle larvae.

6. The downstream degradation of water quality reflected by the changes in the benthic community are detrimental to agricultural, waterfowl and fish production and sport fishing uses of the System.

DESCRIPTION OF STUDY AREA

The Lost River is located along the Oregon-California border with approximately sixty percent of its drainage area in Oregon and the remainder in California. Figures 1, 2, and 3 are maps of the Lost River System showing the general location, sampling stations and agricultural valleys.

The Lost River System is situated in the (U.S. Department of the Interior) Bureau of Reclamation's Klamath Project. The project facilities include: (1) a dam at the outlet of Clear Lake Reservoir which provides a constant flow for irrigation, (2) a channel from Lost River to Klamath River to divert excess Lost River water away from Tule Lake during the flood season and to import Klamath River water to Tule Lake for irrigation during the growing season, and (3) a dam at Upper Klamath Lake. The project can store about 108,000 acre feet of water and irrigate 220,000 acres of land.

The Lost River originates in the mountains east of Clear Lake Reservoir in Modoc County, California, and flows in a northwesterly direction across the Oregon-California boundary (Figure 1). In Oregon it flows northerly, then westerly toward Klamath Falls, Oregon. In this reach, the Lost River flow is augmented by releases from the Klamath River and by springs. In the vicinity of Klamath Falls, Oregon, water stored by the Lost River Diversion Dam, can be entirely diverted to the Klamath River, or left in the river to flow south toward Tule-lake, California.

FIGURE 1
LOCATION MAP
LOST RIVER DRAINAGE

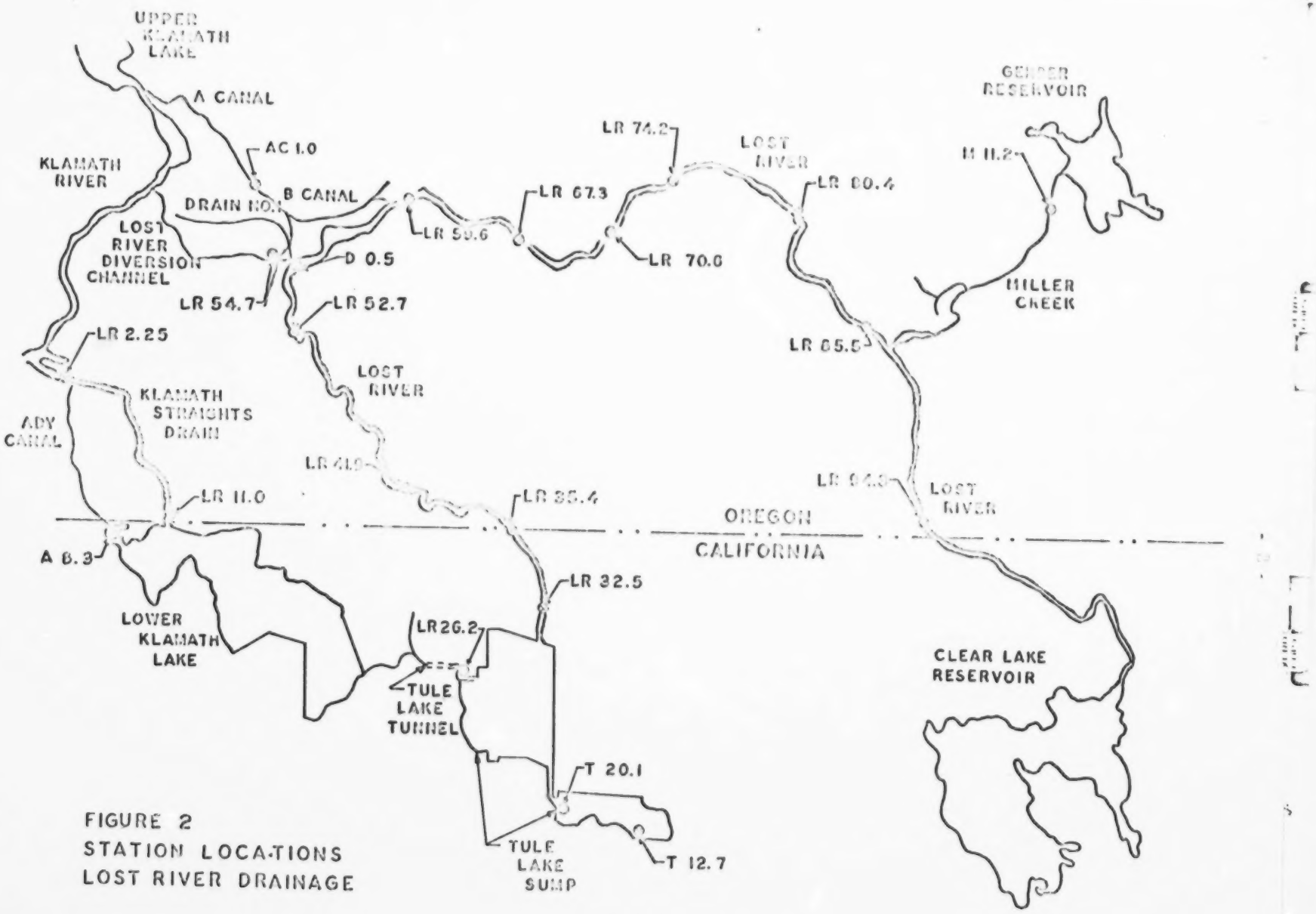

FIGURE 2
STATION LOCATIONS
LOST RIVER DRAINAGE

FIGURE 3
AGRICULTURAL VALLEYS
of the
LOST RIVER DRAINAGE

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Just upstream from the Lost River Diversion Dam (Figure 2) Klamath Lake water can be diverted to the Lost River via "A" and "B" Canals to augment flows during the irrigation season.

At the Lost River Diversion Dam, the Lost River turns and flows south toward Tule Lake. At times the entire flow of the Lost River in Oregon is diverted for agricultural uses. The river terminates at Tule Lake National Wildlife Refuge in California. However, excess waters from the refuge are pumped through a tunnel cut through a mountain range, to the west to Lower Klamath Lake Refuge in California and from Lower Klamath Lake Refuge and the adjacent agricultural area the waters are drained via the Klamath Straits Drain back across the California-Oregon state line and are then pumped into the Klamath River as a part of the Lost River System.

The topography of the System is generally flat with more than one-third of the agricultural area being reclaimed lake bottom. In the agricultural portion of the System, the Lost River falls approximately 100 feet in 135 miles. This low gradient is conducive to slow moving water and silt deposition. The climate is semi-arid, similar to the central Columbia Plateau of Washington and Oregon. The mean temperature during the warmest months is slightly under 70 degrees F. The average annual precipitation in the Klamath Falls area over the past five years has been approximately 14 inches.

Present use of the Lost River System are: irrigation, stock watering, irrigation drainage, domestic waste disposal, recreation, fish propagation and waterfowl refuge sites. The recreational uses are warmwater fishing, waterfowl and frog hunting, and sightseeing. Sightseeing is a major attraction at the National Wildlife Refuges during the annual spring and fall waterfowl migration periods.

METHODS

During a reconnaissance survey in June and July 1964, twenty-one sampling stations were selected in locations where the effects of irrigation dams, diversions, major drains and tributaries could be evaluated. The first sampling period was in December of 1964 after the irrigation season, before the stream was dammed for irrigation diversion. The second sampling period was in April 1965, before the irrigation season, when the water was high due to spring runoff. The last sampling period was in August 1965 during the peak of the irrigation season when the diversion dams were closed and most riffle areas were submerged. Areas with mud bottoms were selected for collecting samples because this type of bottom is typical in the System. During each sampling period, four dredged samples, equally spaced across the stream were collected.

The samples were collected with a standard six-inch Ekman dredge, washed through a U. S. No. 30 sieve and preserved in 10% formalin.

The four quantitative samples collected at each station were combined after laboratory analysis, and considered as a one square foot sample. During the August sampling a qualitative "grab" sample was taken at each station. Tributaries, canals, and drains supplying polluted irrigation return water and clean water to the System were sampled.

All organisms collected were divided into three tolerance classifications (Table I) - (1) clean water, (2) facultative (intermediate),

and (3) pollution tolerant - based upon the associations of bottom organisms found to exist in the Lost River Drainage, and upon the general tolerance classifications described by Keup, Ingram, and Mackenthun (4).

TABLE 1

Tolerance Classification of Lost River Bottom Organisms

Order	Common Name
Pollution Tolerant Organisms	
Oligochaeta	sludgeworms
Diptera	
Tendipedidae	
with ventral gills	bloodworms
Hirudinea	leeches
Facultative Organisms	
Diptera	
Tendipedidae	
without ventral gills	midge larvae
Gastropoda	snails
Amphipoda	scuds
Isopoda	sowbugs
Polecypoda	
Sphaeriidae	fingernail clams
Clean Water Organisms	
Pelecypoda	
Unionidae	large clams
Megaloptera	alder fly larvae
Coleoptera	beetle larvae
Ephemeroptera	mayfly nymphs
Lepidoptera	aquatic moth caterpillars
Trichoptera	caddisfly larvae

Benthic organisms which are known to be capable of leaving the water during periods of stress or moving readily from one body of water to the next were not considered as a part of the benthic community in this report: e. g., dragonfly and damselfly nymphs and adult aquatic beetles.

RESULTS

In the headwater reaches of the Lost River near Malone Dam, populations of clean water associated organisms such as caddisfly and mayfly nymphs, aquatic moth and beetle larvae were collected. In the polluted environment of the lower reaches, mile point 2.25 to 52.7, of the System, (Figure 4), sludgeworms, bloodworms, and leeches were the most abundant of the organisms collected. The change from clean water associated organisms to pollution tolerant organisms was found to be gradual from one downstream valley to the next (Figure 4, Tables 2, 3, and 4).

The numbers of organisms per square foot were much lower (580 per square foot) in the upstream reaches, mile point 54.7 to 94.3, than in the downstream reaches (1,829 per square foot). This contrast persisted through all of the three collecting periods (Figure 5, Table 5).

Superimposed upon the regional differences in numbers were seasonal differences, particularly in the downstream reaches. In December 1964, at the end of the 1964 agricultural irrigation season, the number of organisms collected in the downstream reaches were over 1,800 per square foot.

In April, before the 1965 irrigation season, when no irrigation return water was entering the stream, the number of organisms collected in the downstream reaches remained low (215 organisms per square foot).

In August 1965 during the seasonal increase in and reuse of irrigation return water, the number of organisms collected in the downstream reaches increased to over 1000 per square foot (Figure 5, Table 3).

The effects of riffle areas, water held in impoundments and sumps, and the addition of clean water from springs, Upper Klamath Lake, and the Klamath River improved the water quality of the Lost River (Figure 6).

The number of kinds of organisms and the number of organisms per square foot collected in tributary streams and canals are recorded in Tables 6 and 7. Physical data collected during August 1965 are presented in Table 8.

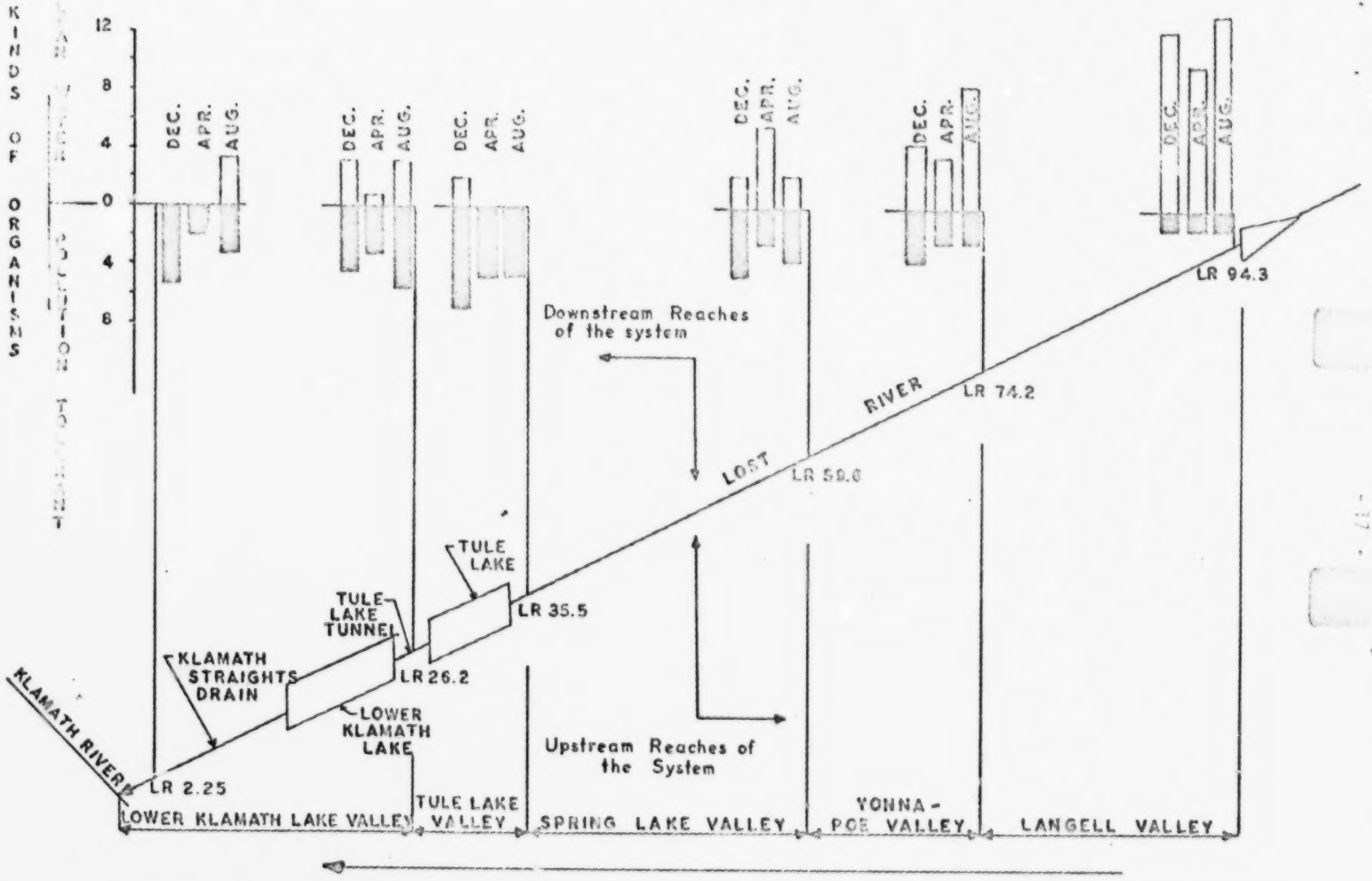

FIGURE 4 - A COMPARISON OF KINDS OF CLEAN WATER ORGANISMS AND POLLUTION TOLERANT ORGANISMS COLLECTED AT THE UPSTREAM AND DOWNSTREAM END OF EACH VALLEY DURING DECEMBER 1964, AND APRIL AND AUGUST 1965.

Table 2. Number of Clean Water Organisms and Pollution Tolerant Organisms Per Square Foot Collected at the Upstream and Downstream End of Each Valley During December 1964, and August, 1965.

		Mile Point 2.25			Mile Point 26.2			Mile Point 35.4			Mile Point 59.6			Mile Point 74.2			Mile Point 94.3		
		Dec	Apr	Aug	Dec	Apr	Aug	Dec	Apr	Aug	Dec	Apr	Aug	Dec	Apr	Aug	Dec	Apr	Aug
Clean Water Organisms	Beetle Larvae	-	-	7	73	-	30	6	-	-	2	13	-	3	62	X	-	-	-
	Mayfly Nymphs	-	-	6	39	-	59	-	-	-	2	20	3	184	17	12	109	24	11
	Caddisfly Larvae	-	-	-	-	4	-	-	-	-	-	3	-	-	-	X	290	53	X
	Large Clams	-	-	-	-	-	-	8	-	-	-	3	-	-	-	X	-	-	-
	Aquatic Moth Caterpillars	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	X
	Alderfly Nymphs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
Pollution Tolerant Organisms	Sludgeworms	2	24	514	294	11	142	74	7	10	122	15	23	60	61	14	4	1	7
	Leeches	57	132	179	109	22	228	479	23	59	46	26	39	69	4	22	-	-	-
	Bloodworms	26	-	206	79	-	51	-	5	7	2	-	-	-	-	-	-	-	-

X - Qualitative Sample

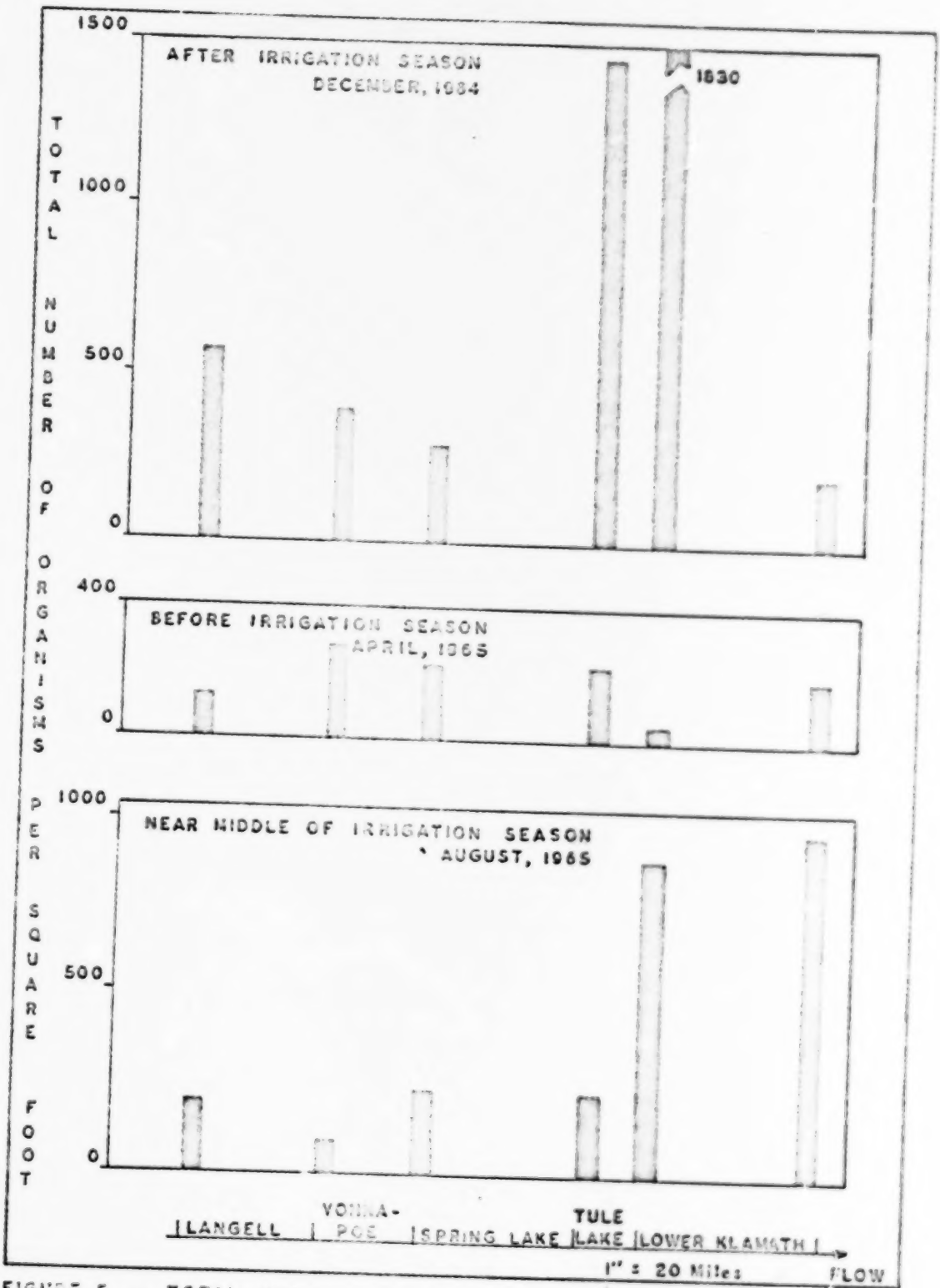

FIGURE 5 - TOTAL NUMBER OF ORGANISMS PER SQUARE FOOT COLLECTED AT THE UPSTREAM AND DOWNSTREAM END OF EACH AGRICULTURAL VALLEY IN THE LOST RIVER SYSTEM.

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TABLE 3. Number of Benthic Macroinvertebrates per Square Foot Collected in December 1964, and April and August 1965.

ORGANISM

Mile	Month	Sludgeworm	Bloodworm	Leeches	Other Midge and Fly Larvae	Snails	Scuds	Sowbugs	Fingernail Clams	Large Clams	Alderfly Larvae	Beetle Larvae	Mayfly Nymphs	Aquatic moth Caterpillars	Caddisfly Larvae	Total organisms per Square Foot
	Dec	4	-	-	116	9	11						109	3	290	543
LR	Apr	1	-	-	31	1	3	-	8	-	-	-	24	1	53	122
94.3	Aug	7	-	-	177	3	X	-	21	-	3	-	11	X	X	222
	Dec	NOT SAMPLED														
LR	Apr	4	-	9	60	28	3	-	16	-	-	5	149	-	1	275
85.5	Aug	276	-	43	726	17	84	-	33	3	-	26	21	-	2	1251
	Dec	57	-	108	97	31	107	-	27	-	-	12	7	-	2	448
LR	Apr	24	-	22	12	1	12	-	8	4	-	15	38	-	-	136
80.4	Aug	11	-	6	72	11	24	-	33	-	-	1	X	-	2	160
	Dec	60	-	69	38	3	21	-	-	1	-	3	184	-	-	379
LR	Apr	61	-	4	129	2	1	-	5	-	-	62	17	-	-	281
74.2	Aug	14	-	22	16	15	3	-	7	4	-	X	12	-	X	93
	Dec	139	-	26	12	978	33	-	59	-	-	50	1	-	-	1298
LR	Apr	36	-	14	1322	146	63	7	23	1	-	2	19	1	9	1643
70.6	Aug	45	-	12	55	288	90	8	33	-	-	-	7	X	X	538
	Dec	326	-	4	502	44	272	-	2	-	-	12	97	2	46	1307
LR	Apr	23	-	36	253	343	83	1	19	-	-	18	6	-	-	782
67.3	Aug	45	-	6	48	125	205	-	86	-	-	-	189	2	108	814
	Dec	122	2	46	58	61	10	-	-	-	-	2	2	-	-	303
LR	Apr	15	-	26	37	46	62	-	9	-	-	13	20	-	3	231
59.6	Aug	23	-	39	89	21	69	-	7	-	-	-	3	-	-	251
	Dec	85	13	25	53	712	300	-	18	2	-	2	61	-	-	1271
LR	Apr	42	-	24	27	193	66	-	24	1	4	2	20	-	-	403
54.7	Aug	18	-	77	17	165	6	-	8	4	-	6	2	-	-	303
	Dec	211	-	10	5	15	-	-	1	-	-	-	-	-	-	242
LR	Apr	8	12	20	63	-	-	-	1	1	-	1	-	-	-	106
52.7	Aug	112	X	44	35	65	3	-	9	1	-	-	3	-	-	272
	Dec	239	-	165	18	44	-	-	8	-	-	1	1	-	-	476
LR	Apr	42	-	30	22	14	-	-	4	-	-	2	-	-	-	114
41.9	Aug	152	64	135	1	31	3	-	10	1	-	1	1	-	-	399
	Dec	74	-	479	3	751	67	-	83	8	-	6	-	-	-	1471
LR	Apr	9	5	23	123	8	47	-	-	-	-	-	-	-	-	215
35.4	Aug	10	7	59	-	124	33	-	7	-	-	-	-	-	-	240
	Dec	368	212	11	-	4	-	-	-	-	-	-	-	-	-	595
LR	Apr	NOT SAMPLED														
32.5	Aug	540	585	3	-	7	8	-	-	-	-	-	-	-	-	1143
	Dec	294	79	109	11	380	842	-	-	-	-	73	39	-	-	1827
LR	Apr	11	-	22	4	-	7	-	-	-	-	-	-	-	4	48
26.2	Aug	142	51	228	-	129	289	-	-	-	-	30	59	-	-	928
	Dec	23	69	11	-	-	-	-	-	-	-	-	2	-	-	105
LR	Apr	3	549	33	-	-	50	-	-	-	-	-	1	-	-	636
11.0	Aug	20	27	X	1	X	3	-	-	-	-	-	-	-	-	51
	Dec	2	26	57	24	60	-	-	36	-	-	-	-	-	-	205
LR	Apr	24	-	132	11	12	4	-	19	-	-	-	-	-	-	202
2.25	Aug	514	206	179	-	64	13	-	56	-	-	7	6	-	-	1045

Qualitative Sample

TABLE 4. Number of Kinds of Benthic Macroinvertebrates collected in December 1964, and April and August 1965.

Mile	Month	Sludgeworm	Bloodworm	Leeches	Other Midge and Fly Larvae	Snails	Scuds	Sowbugs	Fingernail Clams	Large Clams	Alderfly Larvae	Beetle Larvae	Mayfly Nymphs	Aquatic Moth Caterpillars	Caddisfly Larvae	Total Kinds	Pollution Tolerant Kinds	Clean Water Kinds
	Dec	1	-	-	3	2	1	-	-	-	1	-	6	1	3	18	1	11
LR	Apr	1	-	-	1	1	1	-	2	-	-	-	5	1	3	15	1	9
94.3	Aug	1	-	-	1	2	1	-	1	-	1	-	7	1	3	18	1	12
	Dec	NOT SAMPLED																
LR	Apr	1	-	1	1	2	1	-	2	-	-	2	3	-	1	14	2	6
85.5	Aug	1	-	2	1	4	1	-	1	1	-	2	5	-	2	20	3	10
	Dec	1	-	2	3	5	1	-	1	-	-	2	3	-	2	20	3	7
LR	Apr	1	-	2	2	1	1	-	1	2	-	2	3	-	-	15	3	7
80.4	Aug	1	-	2	2	4	1	-	1	-	-	1	2	-	2	16	3	5
	Dec	1	-	2	2	1	1	-	-	1	-	1	2	-	-	11	3	4
LR	Apr	1	-	1	2	2	1	-	1	-	-	1	2	-	-	11	2	3
74.2	Aug	1	-	1	2	2	1	-	1	1	-	1	4	-	2	16	2	6
	Dec	1	-	2	2	2	1	-	1	-	-	1	1	-	-	11	3	2
LR	Apr	1	-	1	2	3	1	1	1	1	-	2	3	1	3	20	2	9
70.6	Aug	1	-	2	1	3	1	1	1	-	-	-	3	1	2	16	3	6
	Dec	1	-	2	2	4	1	-	1	-	-	2	2	1	1	17	3	6
LR	Apr	1	-	2	2	2	1	1	1	-	-	1	2	-	-	13	3	3
67.3	Aug	1	-	2	2	1	1	-	2	-	-	-	4	1	2	16	3	7
	Dec	1	1	2	2	7	1	-	-	-	-	1	1	-	-	16	4	2
LR	Apr	1	-	1	2	4	1	-	1	-	-	1	3	-	1	15	2	5
59.6	Aug	1	-	2	3	5	1	-	1	-	-	-	2	-	-	15	3	2
	Dec	1	1	2	3	7	1	-	1	1	-	1	3	-	-	21	4	5
LR	Apr	1	-	3	1	6	1	-	1	1	1	1	1	-	-	17	4	4
54.7	Aug	1	-	3	1	4	1	-	1	2	-	2	1	-	-	16	4	5
	Dec	1	-	2	1	2	-	-	1	-	-	-	-	-	-	7	3	0
LR	Apr	1	1	2	1	-	-	-	1	1	-	1	-	-	-	8	5	2
52.7	Aug	1	1	2	2	2	1	-	1	1	-	-	2	-	-	13	5	3
	Dec	1	-	3	1	3	-	-	1	-	-	1	1	-	-	11	4	2
LR	Apr	1	-	2	1	2	-	-	1	-	-	1	-	-	-	8	3	1
41.9	Aug	1	1	2	2	6	1	-	1	1	-	1	1	-	-	17	4	3
	Dec	1	-	4	1	8	1	-	1	1	-	1	-	-	-	18	5	2
LR	Apr	1	1	2	2	4	1	-	-	-	-	-	-	-	-	11	5	0
35.4	Aug	1	1	2	-	5	1	-	1	-	-	-	-	-	-	11	5	0
	Dec	1	1	2	-	2	-	-	-	-	-	-	-	-	-	6	4	0
LR	Apr	NOT SAMPLED																
32.5	Aug	1	1	1	-	3	1	-	-	-	-	-	-	-	-	7	3	0
	Dec	1	1	2	1	5	1	-	-	-	-	1	2	-	-	14	4	3
LR	Apr	1	-	2	1	-	1	-	-	-	-	-	-	-	1	6	3	0
26.2	Aug	1	1	3	-	4	1	-	-	-	-	1	2	-	-	13	5	3
	Dec	1	1	3	-	-	-	-	-	-	-	-	1	-	-	6	5	1
LR	Apr	1	1	3	-	-	1	-	-	-	-	-	1	-	-	7	5	1
11.0	Aug	1	1	1	1	2	1	-	-	-	-	-	-	-	-	7	3	0
	Dec	1	1	2	1	1	-	-	1	-	-	-	-	-	-	7	4	0
LR	Apr	1	-	1	1	2	1	-	1	-	-	-	-	-	-	7	2	0
2.25	Aug	1	1	1	-	4	1	-	1	-	-	1	2	-	-	12	3	3

Table 5

Number of Benthic Macroinvertebrates per Square Foot Collected at the Head and Foot of Each of the Agricultural Valleys

	Station Number and Valley																		
	LR 94.3		Langell Valley	LR 74.2		Yonna-Poe Valley		LR 59.6		Spring Lake Valley		LR 35.4	Tule Lake Valley	LR 26.2	Lower Klamath Valley		LR 2 25		
	Dec	Apr	Aug	Dec	Apr	Aug	Dec	Apr	Aug	Dec	Apr	Aug	Dec	Apr	Aug	Dec	Apr	Aug	
Sludgeworms	4	1	7	60	61	14	122	15	23	74	9	10	294	11	142	2	24	514	
Bloodworms with ventral gills	-	-	-	-	-	-	2	-	-	-	5	7	79	-	51	26	-	206	
Leeches	-	-	-	69	4	22	46	26	39	479	23	59	109	22	228	57	132	179	
Other midge and fly larvae	153	31	177	38	129	16	58	37	89	3	123	-	11	4	-	24	11	-	
Snails	9	1	2	3	2	15	61	46	21	751	8	124	380	-	129	60	12	64	
Scuds	11	3	X*	21	1	3	10	62	69	67	47	33	842	7	289	-	4	13	
Sowbugs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Fingernail Clams	-	8	21	-	5	7	-	9	7	83	-	7	-	-	-	36	19	56	
Large Clams	-	-	-	1	-	4	-	-	-	8	-	-	-	-	-	-	-	-	
Alder flies	1	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Beetle larvae	-	-	-	3	62	X*	2	13	-	6	-	-	73	-	30	-	-	7	
Mayflies	109	24	11	184	17	12	2	20	3	-	-	-	39	-	59	-	-	6	
Aquatic Moths	3	1	X*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Caddisfly	290	53	X*	-	-	X*	-	3	-	-	-	-	-	4	-	-	-	-	
TOTAL	580	122	221	379	281	93	303	231	251	1471	215	240	1827	48	938	205	202	1045	

* Qualitative collection

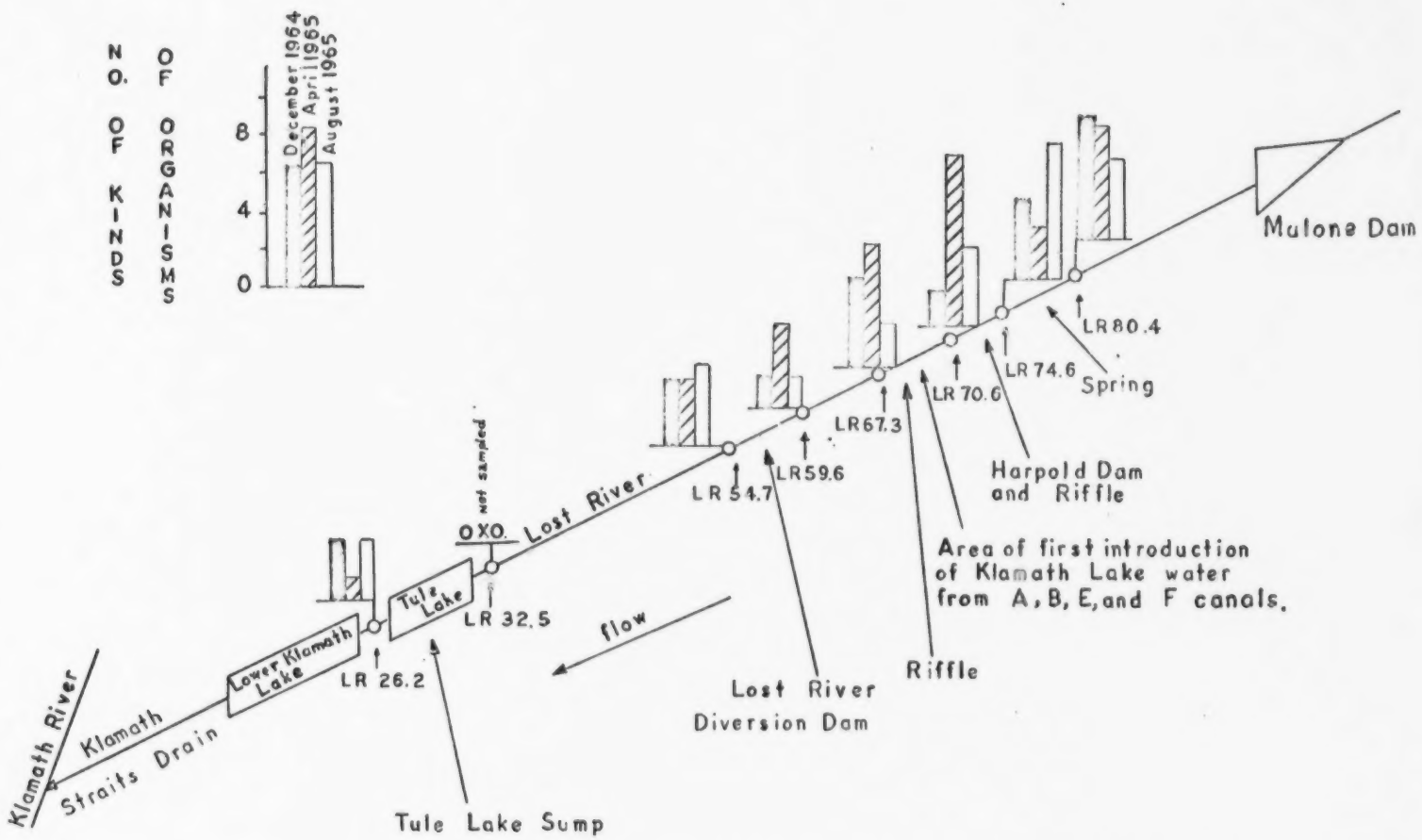

Figure 6 - Comparison of number of clean water organisms upstream and downstream from sumps, impoundments, riffles, and clean water sources collected during December 1964 and April and August 1965.

TABLE 6. Number of Kinds of Macroinvertebrates Collected at Tributary Stations in December 1964, and April and August 1965.

Mile	Month	ORGANISM																	
		Sludgeworm	Bloodworm	Leeches	Other Midge and Fly Larvae	Snails	Scuds	Sowbugs	Fingernail Clams	Large Clams	Alderfly Larvae	Beetle Larvae	Mayfly Nymphs	Aquatic moth Caterpillars	Caddisfly Larvae	Total Kinds	Pollution Tolerant Kinds	Clean Water Kinds
M	Dec	1	-	1	1	3	1	-	1	-	-	-	1	-	1	10	2	2
	Apr	1	-	-	1	1	-	-	2	-	-	-	3	-	3	11	1	6
11.2	Aug	1	-	1	1	6	1	-	1	-	-	1	3	-	1	16	2	5
	Dec	NOT SAMPLED																
D	Apr	1	-	2	1	1	1	-	-	-	-	-	1	-	1	8	3	2
0.5	Aug	1	-	2	1	1	1	-	-	-	1	1	2	-	-	10	3	4
	Dec	NOT SAMPLED																
T	Apr	1	1	1	-	1	1	-	-	-	-	-	-	-	-	5	3	0
20.1	Aug	1	1	3	-	2	1	-	-	-	-	-	2	-	-	10	4	2
	Dec	1	-	2	1	6	1	-	1	-	-	-	2	-	-	14	3	2
T	Apr	1	-	2	-	6	1	-	1	-	-	1	-	-	-	12	3	1
12.7	Aug	1	1	2	-	3	1	-	1	-	-	1	2	-	-	12	4	3
	Dec	1	1	4	-	4	1	-	-	-	-	-	-	-	-	11	6	0
A	Apr	1	-	1	2	2	1	-	1	-	-	-	-	-	-	8	2	0
	Aug	1	1	3	-	-	1	-	-	-	-	2	1	-	-	9	5	3
	Dec	NOT SAMPLED																
AC	Apr	NOT SAMPLED																
	Aug	-	-	2	2	4	2	-	1	-	-	2	2	-	2	17	2	6

Table 7. Number of Benthic Macroinvertebrates per Square Foot Collected at Tributary Stations in December 1964 and April and August 1965.

Mile	Month	Sludgeworms	Bloodworms	Leeches	Other Midge and Fly Larvae	Snails	Scuds	Sowbugs	Fingernail Clams	Large Clams	Alderfly Larvae	Beetle Larvae	Mayfly Nymphs	Aquatic Moth Caterpillars	Caddisfly Larvae	Total Organisms per Square Foot
	Dec	143	-	-	207	37	39	-	143	-	-	-	12	-	43	625
M	Apr	108	-	-	140	4	-	-	34	-	-	-	31	-	152	469
11.2	Aug	130	-	3	1406	34	9	-	59	-	-	1	5	-	92	1739
	Dec			NOT SAMPLED												
D	Apr	17	-	15	12	2	5	-	-	-	-	-	1	-	2	54
0.5	Aug	8	-	6	27	1	14	-	-	-	X	X	X	-	-	56
	Dec			NOT SAMPLED												
T	Apr	16	152	4	-	2	28	-	-	-	-	-	-	-	-	202
20.1	Aug	374	765	71	-	5	20	-	-	-	-	-	8	-	-	1243
	Dec	6511	-	131	2	16	13	-	76	-	-	-	5	-	-	6754
T	Apr	140	-	212	-	69	33	-	71	-	-	5	-	-	-	530
12.7	Aug	25	104	124	-	34	5	-	30	-	-	4	2	-	-	328
	Dec	375	93	343	-	24	8	-	-	-	-	-	-	-	-	843
A	Apr	141	-	88	14	5	32	-	4	-	-	-	-	-	-	284
8.3	Aug	372	674	38	-	-	8	-	-	-	-	2	4	-	-	1098
	Dec			NOT SAMPLED												
AC	Apr			NOT SAMPLED												
	Aug	-	-	2492	12700	4	500	-	370	-	-	5	42	-	28	16141

X - Qualitative Sample

LOST RIVER SYSTEM
PHYSICAL DATA
AUGUST 1965

TABLE 8

STATION NO.	HABITAT TYPE	WIDTH FEET	MAXIMUM DEPTH FEET	SURFACE VELOCITY FT/SEC	WATER COLOR
LR 94.3	Rock, gravel, mud, sand	40	3.5	1.8	Brown
LR 85.5	Sand, silt, and mud	60	4	0.5	Clear
LR 80.4	Sand, mud, clay	50	4	1.5-2	Clear
LR 74.2	Silt & mud	75	8	0.5	Murky Brown
LR 70.6	Rock, sand, mud	50	5	0.6	Yellow
LR 67.3	Clay & Hard mud	50	2	1.4	Clear
LR 59.6	Gravel, sand, mud, & silt	130	12	0.3	Murky Brown
LR 54.7	Mud	70	12	0.5	Tan
LR 52.7	Rock, gravel, sand, mud and silt	40	10	1.0	Brown
LR 41.9	Gravel, sand, deep silt	80	8	0.7	Tan
LR 35.4	Mud, sand, sludge, & silt	60	4	0.7	Yellow
LR 32.5	Hard mud & silt	100	4	0.2	Yellowish
LR 26.2	Sand, mud, & sludge	60	6	0.9	Yellow
LR 11.0	Hard mud sludge	20	4	1.7	Murky Brown

TABLE 8
Cont'd

STATION NO.	HABITAT TYPE	WIDTH FEET	MAXIMUM DEPTH FEET	SURFACE VELOCITY FT/SEC	WATER COLOR
LR 2.25	Sludge, mud, & deep silt	40	10	0.9	Murky Brown
AC	Sand	60	10	1.5	Tan
D 0.5	Sand, silt & mud	30	4	1.3	Brown
T 20.1	Hard mud, sludge	20	8	0	Tan
T 12.7	Silt & sludge	40	6	0	Brown
A 8.3	Sand, sludge & detritus	50	10	-	Brown
M 11.2	Rock, gravel, sand, mud	70	3	1.7	Grey

DISCUSSION

The occurrence of symptomatic groups of species of benthic organisms in clean and in polluted waters was shown many years ago (Shelford, 1913[6], and Odum, 1959[7]). Mayfly nymphs, caddisfly and beetle larvae are typical of the groups that are symptomatic of clean water, while sludgeworms, leeches, and bloodworms are typical of the groups symptomatic of polluted water.

The benthic populations found in the survey of Lost River followed that arrangement with admirable precision.

Irrigation return water carries pollutants such as salts, nutrients, silt, and sometimes pesticides, all of which are detrimental to water quality and inimical in varying degrees to clean water associated organisms. Visual observations of the entire Lost River System revealed discharges of irrigation return water from 215,000 irrigated acres in the entire 94 mile reach to the Klamath River. This return water is discharged into the System through pipes, ditches, pumps, direct runoff, and ground water percolation. The effects of this effluent drainage on the benthos of the Lost River are cumulative. This was demonstrated by the downstream increase in total number of organisms per square foot and by the downstream decrease in number of kinds of clean water associated organisms. In addition to natural enrichment and siltation, this change in population density is due to the downstream increase in nutrient and silt transported to the river by irrigation return water. The silt and nutrient load in the downstream

reaches of the System limits the association of benthic organisms to pollution tolerant kinds. These changes in the benthic communities demonstrate the detrimental effects to water uses by pollution from irrigation return water and the changes of water quality of the Lost River System.

Water in the Lost River is used for recreation, irrigation, stock watering, domestic waste transport and to maintain constant water levels in the Tule Lake and Lower Klamath National Wildlife Refuges during the waterfowl nesting season. The water use most affected by this downstream degradation in water quality is recreation. Warmwater fish that exist in abundance in the upstream reaches of the System are nonexistent in the downstream reaches. The warmwater fishery existing in the upper reaches is used extensively throughout the year. The lower reaches are available to the public and would provide a usable fishery if the water was not polluted. The cumulative downstream buildup of agricultural pollutants has decreased the usability of the water for irrigation in the downstream reaches where the water is considered less desirable for application to high value crops by the farmers. The water supply in the Lower Klamath Lake Valley has been augmented with a more desirable water from the Klamath River. Water is also drawn from the Klamath River to supply the needs of the Lower Klamath National Wildlife Refuge. This is done because water is pumped out of the Tule Lake creating a shortage of water during critical nesting periods.

Differences in the seasonal variations of the upstream and downstream reaches of the System show the impact of irrigation return water upon biota. Observations of the entire system revealed a major increase in the amount of irrigation return water entering this downstream reach of the System as compared to the upstream reach. These increased amounts of return water are reflected in the changes of the benthic organism communities found throughout the System.

Water quality improvement was observed in areas of physical changes such as: riffles, impoundments, and clean water sources. This improvement is evidenced by the increase in number of kinds of clean water associated organisms collected from areas located below riffles, impoundments and sumps, and clean water sources (Figure 6). The most pronounced habitat improvement was observed between mile points 26.2 and 32.5. This was due to the water's being held in the Tule Lake Sumps, allowing the solids, nutrients, and other agricultural pollutants to settle or dissipate before the water was pumped into the Lower Klamath Refuge area. Another area of marked habitat improvement was between mile points 54.7 and 59.6. Here water is impounded and held by the Lost River Diversion Dam (Figures 1 and 6). The remaining areas with downstream increases in number of kinds of clean water associated organisms indicate seasonal improvements of habitat (Figure 6).

For the benefit of all the people who use Lost River water, water management practices should be devised which will not only retain the water quality of the upstream reaches but also will restore a quality of water in the downstream reaches that will enhance populations of benthos that will provide better foods for fish and wildfowl in turn enhancing recreation and the Federal wetlands and wildlife management areas.

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